US009756449B2

(12) **United States Patent**
Van Der Wijst

(10) **Patent No.: US 9,756,449 B2**
(45) **Date of Patent: Sep. 5, 2017**

(54) **METHOD AND DEVICE FOR PROCESSING SOUND DATA FOR SPATIAL SOUND REPRODUCTION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 110 days.

(21) Appl. No.: **14/129,024**

(22) PCT Filed: **Jun. 25, 2012**

(86) PCT No.: **PCT/NL2012/050447**

§ 371 (c)(1),
(2), (4) Date: **Dec. 23, 2013**

(87) PCT Pub. No.: **WO2012/177139**

PCT Pub. Date: **Dec. 27, 2012**

(65) **Prior Publication Data**

US 2014/0126758 A1 May 8, 2014

(30) **Foreign Application Priority Data**

Jun. 24, 2011 (NL) 2006997

(51) **Int. Cl.**
H04S 7/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H04S 7/303*** (2013.01); ***H04S 7/304*** (2013.01); *H04S 2400/11* (2013.01)

(58) **Field of Classification Search**
CPC H04S 7/302–7/304; H04S 2400/11
See application file for complete search history.

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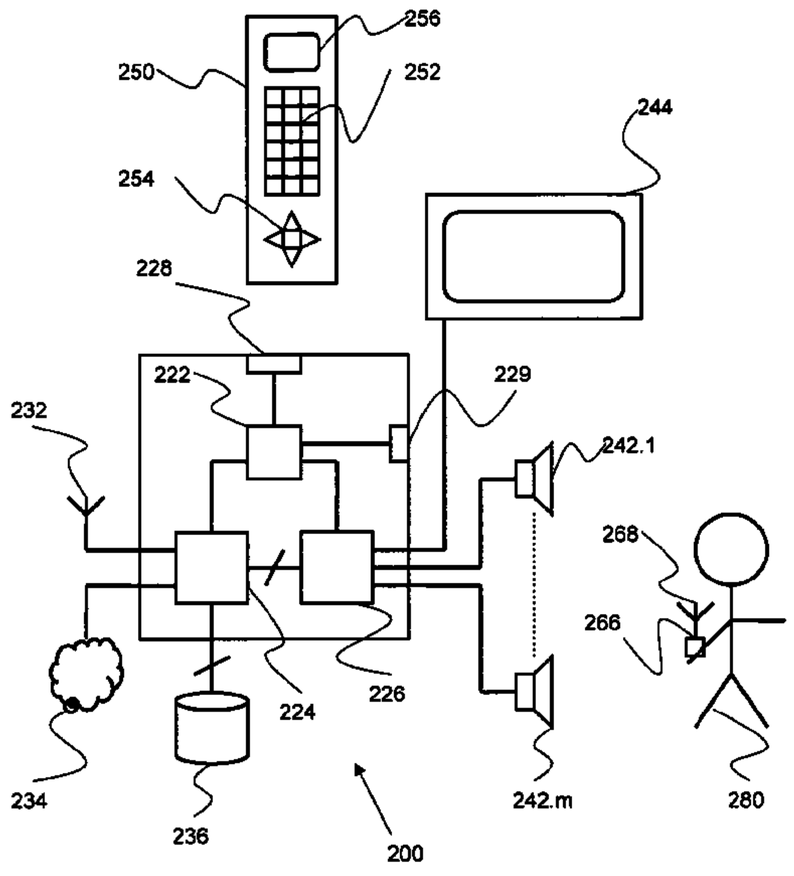
(57) **ABSTRACT**

The invention relates to a method and device for processing sound data comprising determining a listener position; determining a virtual sound source position; receiving sound data; processing the sound data for reproduction by at least one speaker to let the listener perceive the processed sound data reproduced by the speaker to originate from the virtual sound position. This provides the listener with a realistic experience of sound by the speaker. Implementation of the invention allows sound data to be provided also in a dynamic environment, where positions of the listener, the virtual sound source or both can change. For example, sound data may be reproduced by a mobile device by means of headphones to a moving listener, where the virtual sound source is a shop. As the listener moves, the sound data is processed such that when reproduced via the headphones, it is perceived as to originate from the shop.

11 Claims, 10 Drawing Sheets



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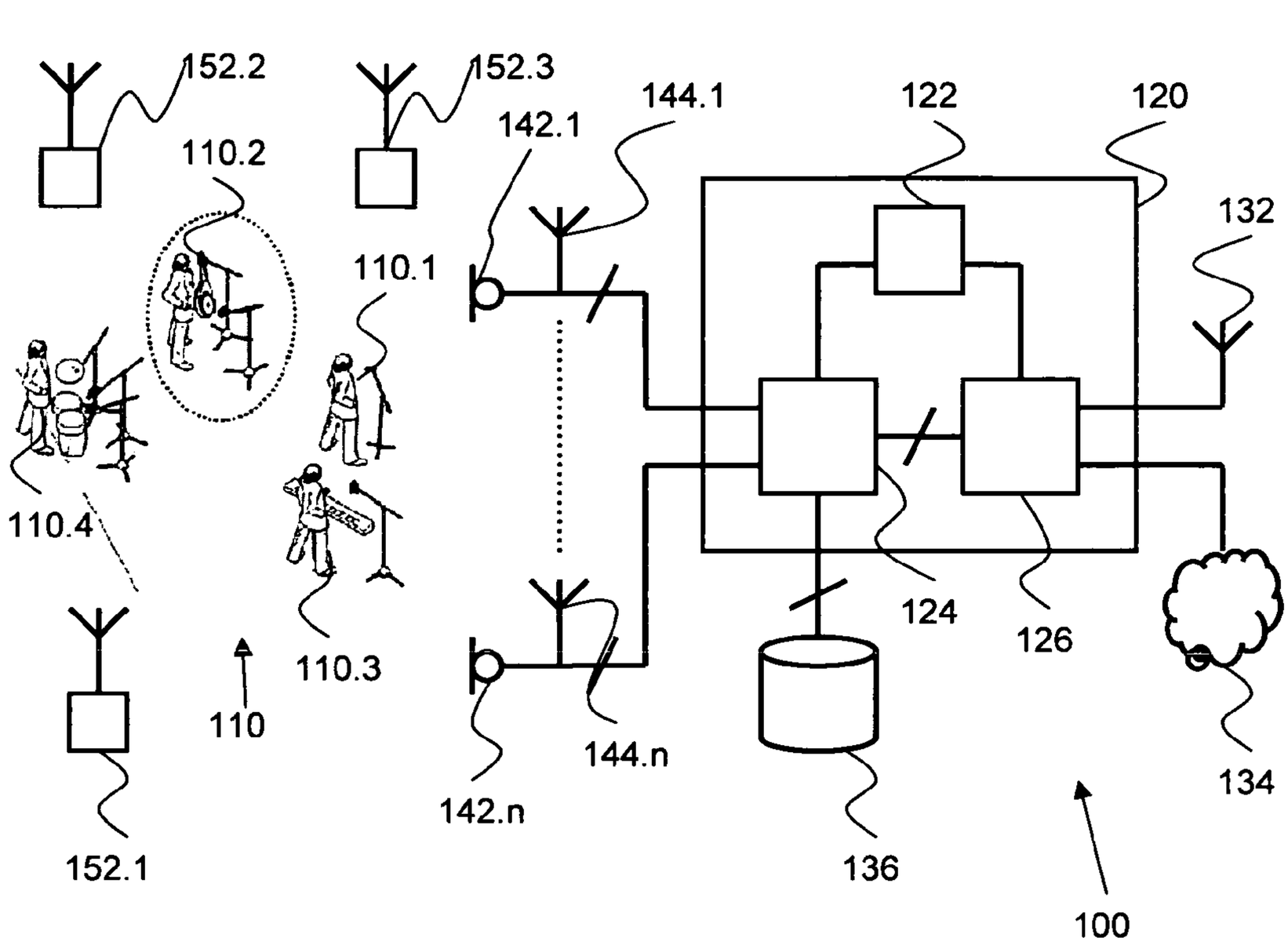
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152.3
110.2
144.1
142.1
122
120
132
110.1
110.4
110.3
110
124
126
144.n
142.n
134
152.1
136
100

Fig. 1

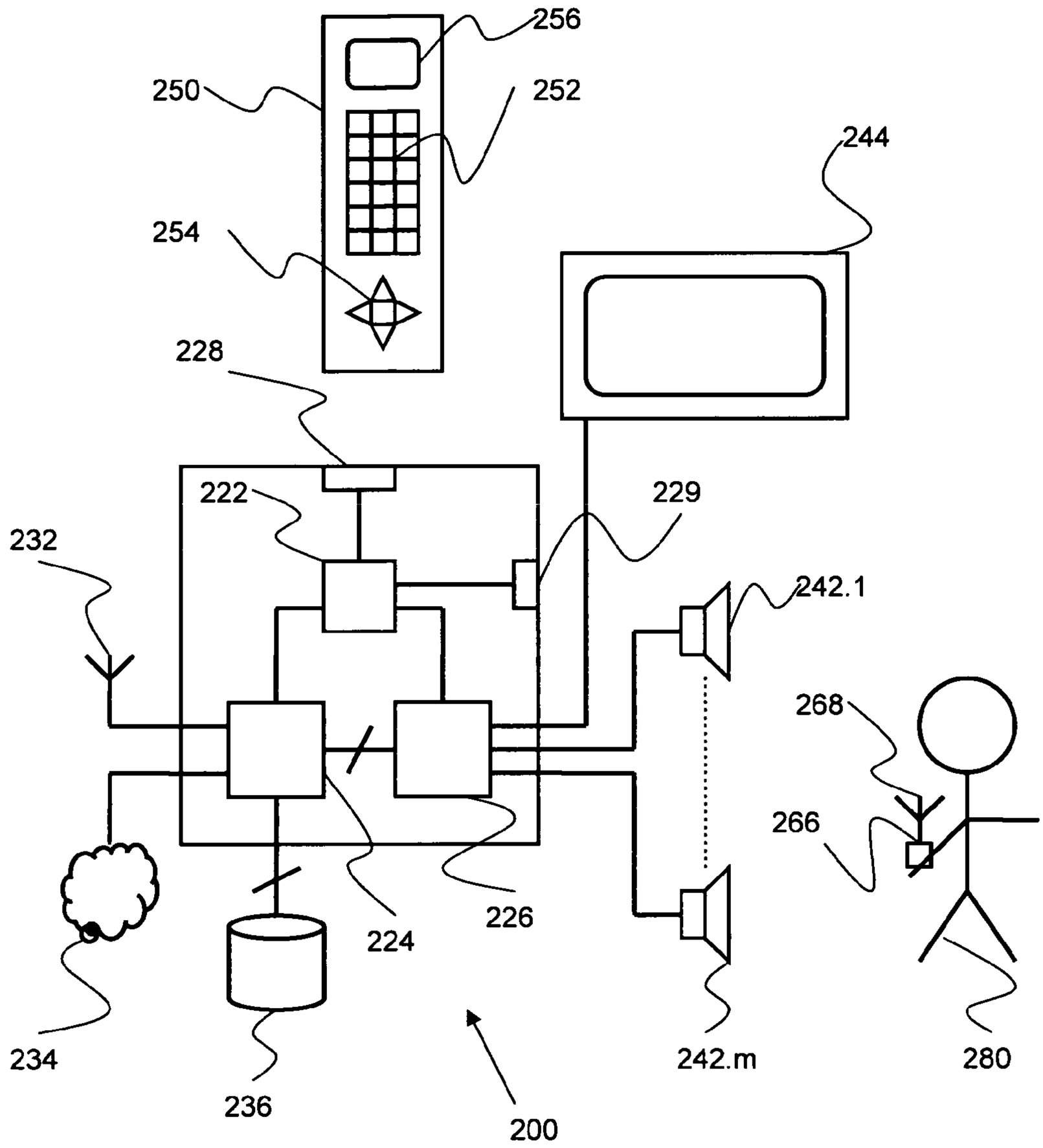

256
250
252
244
254
228
222
229
232
242.1
268
266
224
226
234
236
200
242.m
280

Fig. 2

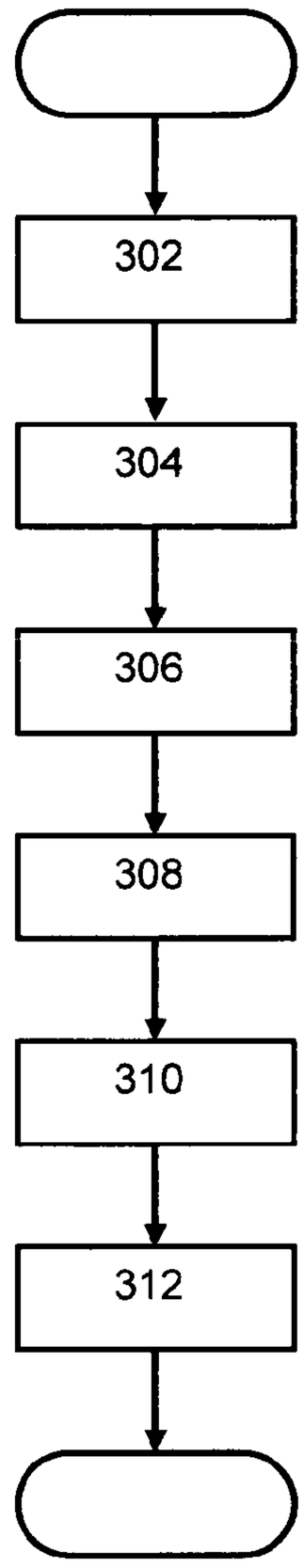


Fig. 3

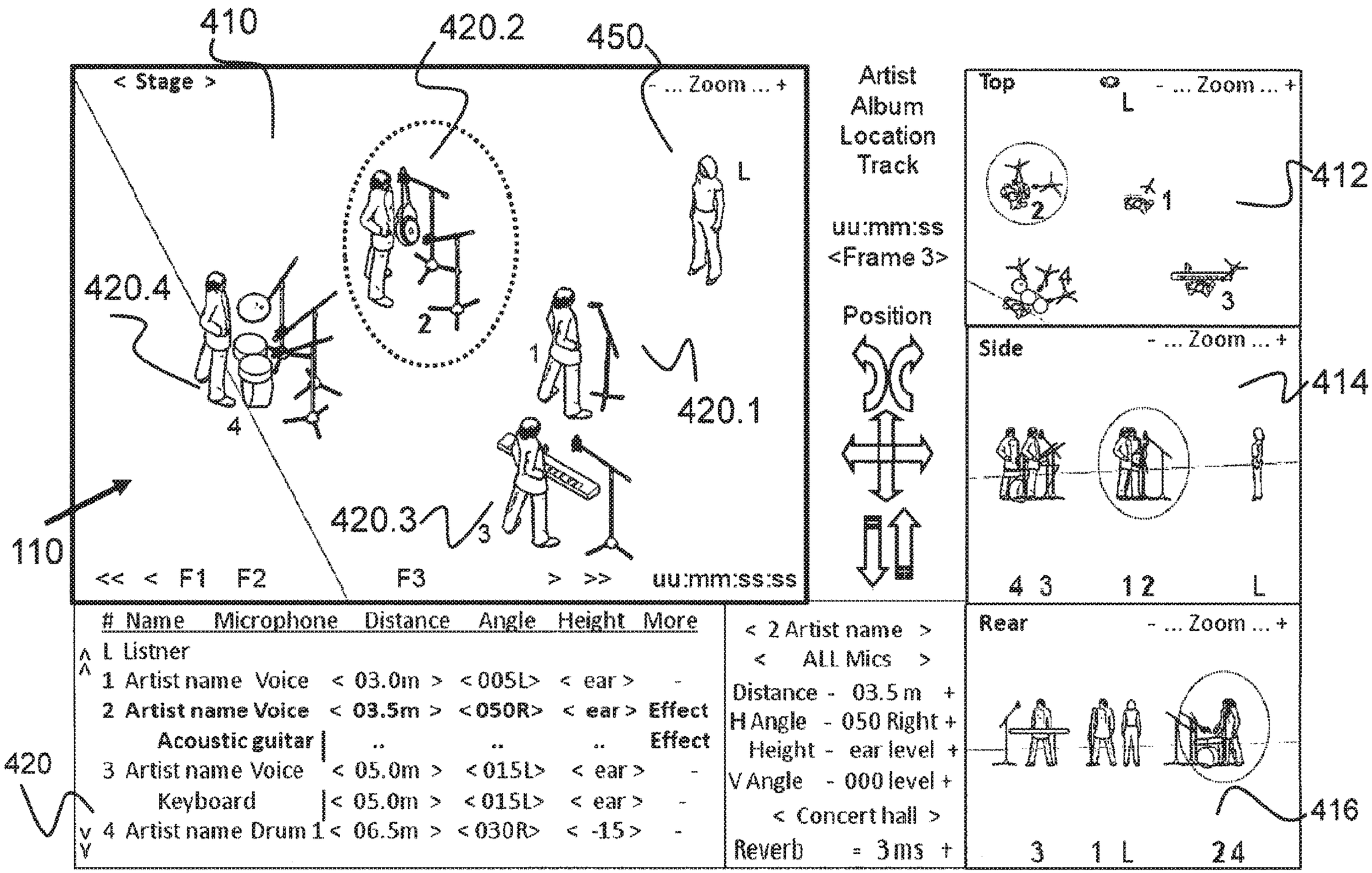

410
420.2
450
< Stage >
- ... Zoom ... +
L
420.4
2
1
420.1
4
420.3
3
110
<< < F1 F2 F3 > >> uu:mm:ss:ss
Artist
Album
Location
Track
uu:mm:ss
<Frame 3>
Position
Top
L
- ... Zoom ... +
412
2
1
4
3
Side
- ... Zoom ... +
414
4 3 12 L
Name Microphone Distance Angle Height More
L Listner
1 Artist name Voice < 03.0m > < 005L> < ear > -
2 Artist name Voice < 03.5m > < 050R> < ear > Effect
Acoustic guitar .. .. .. Effect
3 Artist name Voice < 05.0m > < 015L> < ear > -
Keyboard < 05.0m > < 015L> < ear > -
4 Artist name Drum 1 < 06.5m > < 030R> < -15 > -
420
< 2 Artist name >
< ALL Mics >
Distance - 03.5 m +
H Angle - 050 Right +
Height - ear level +
V Angle - 000 level +
< Concert hall >
Reverb = 3 ms +
Rear
- ... Zoom ... +
416
3 1 L 24

Fig. 4

400

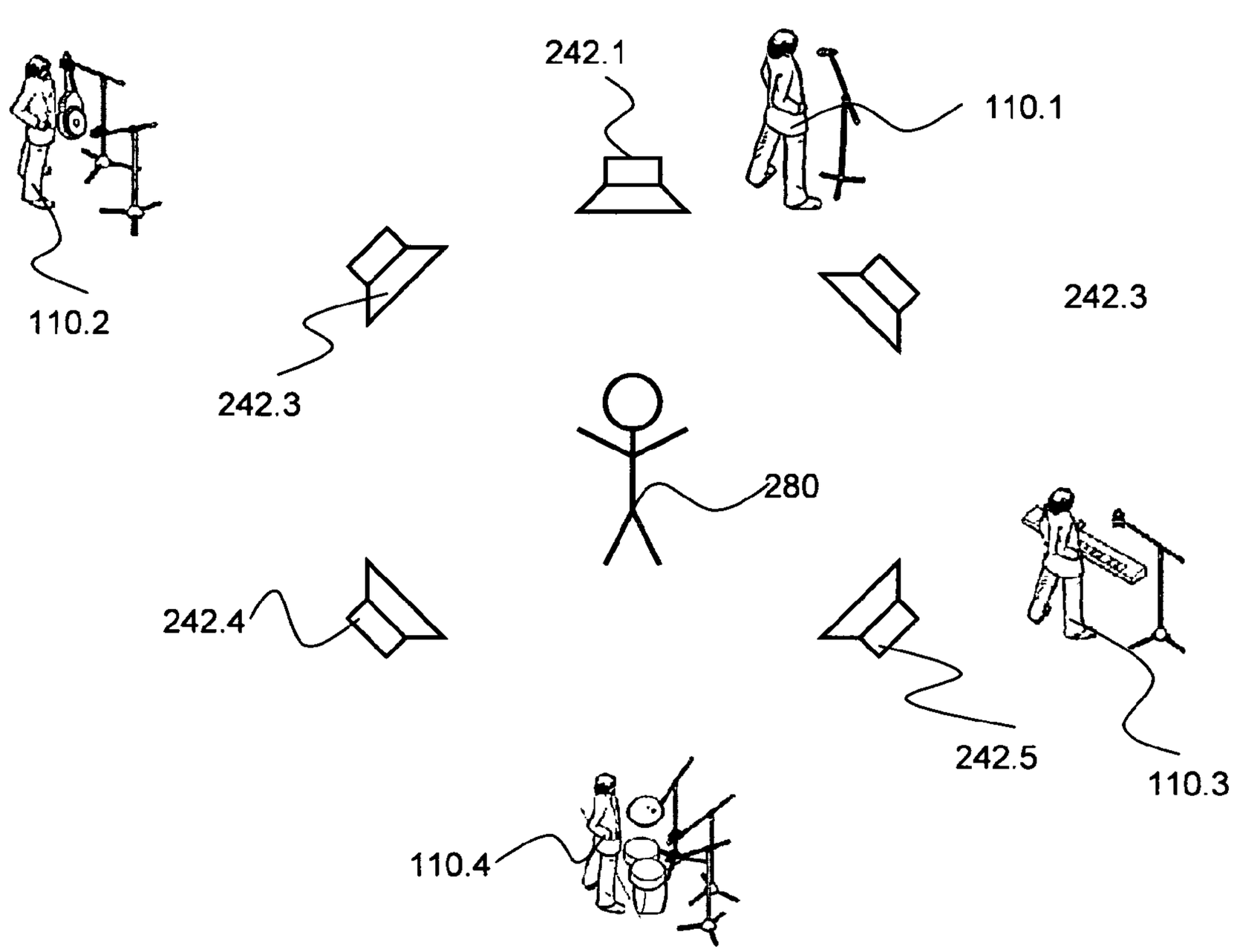
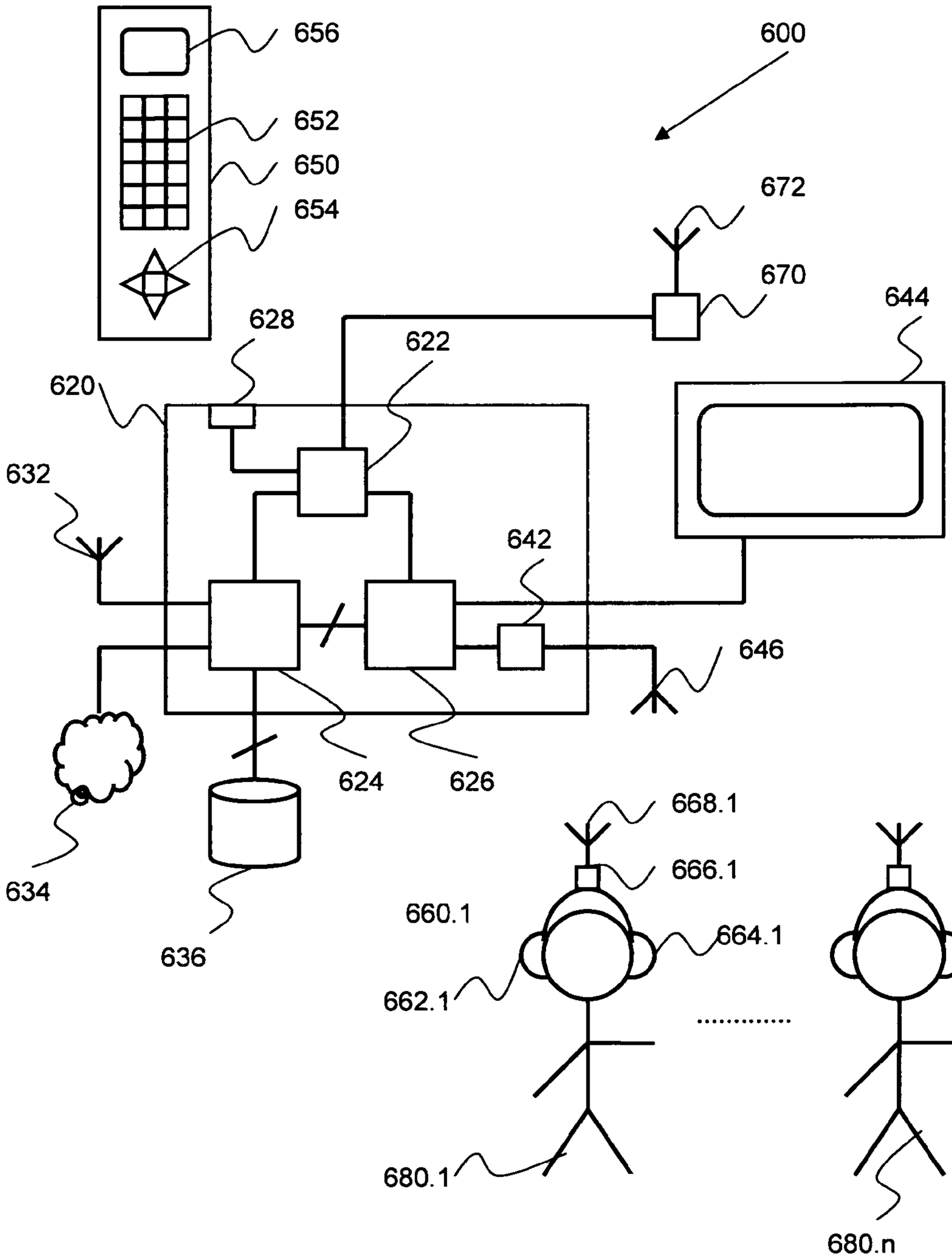


Fig. 5


656
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622
620
632
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666.1
660.1
664.1
662.1
680.1
680.n

Fig. 6 A

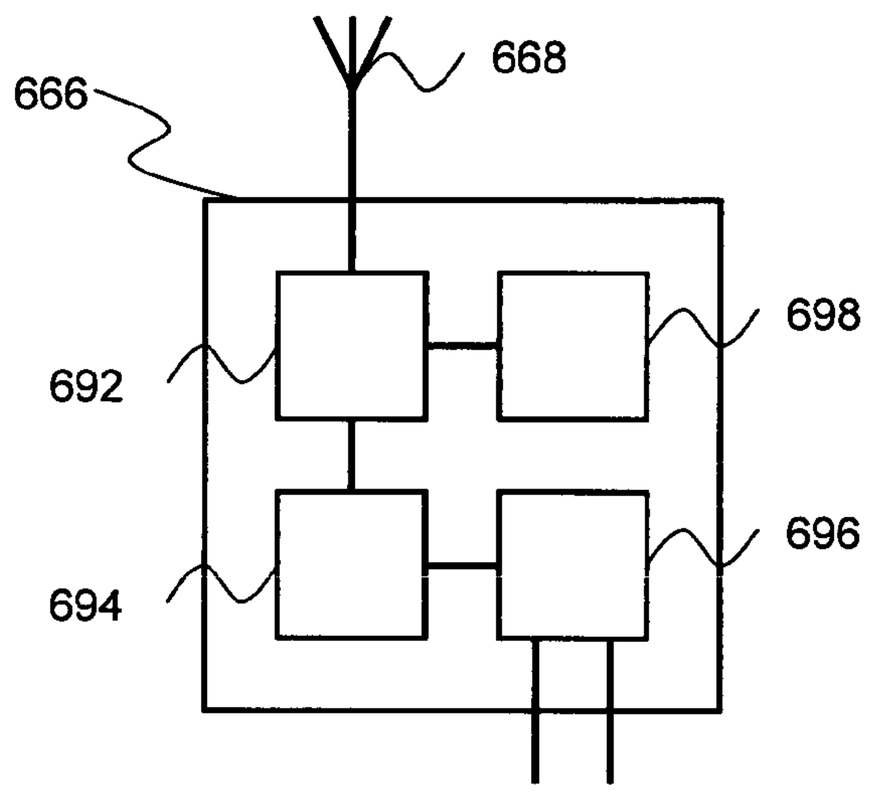
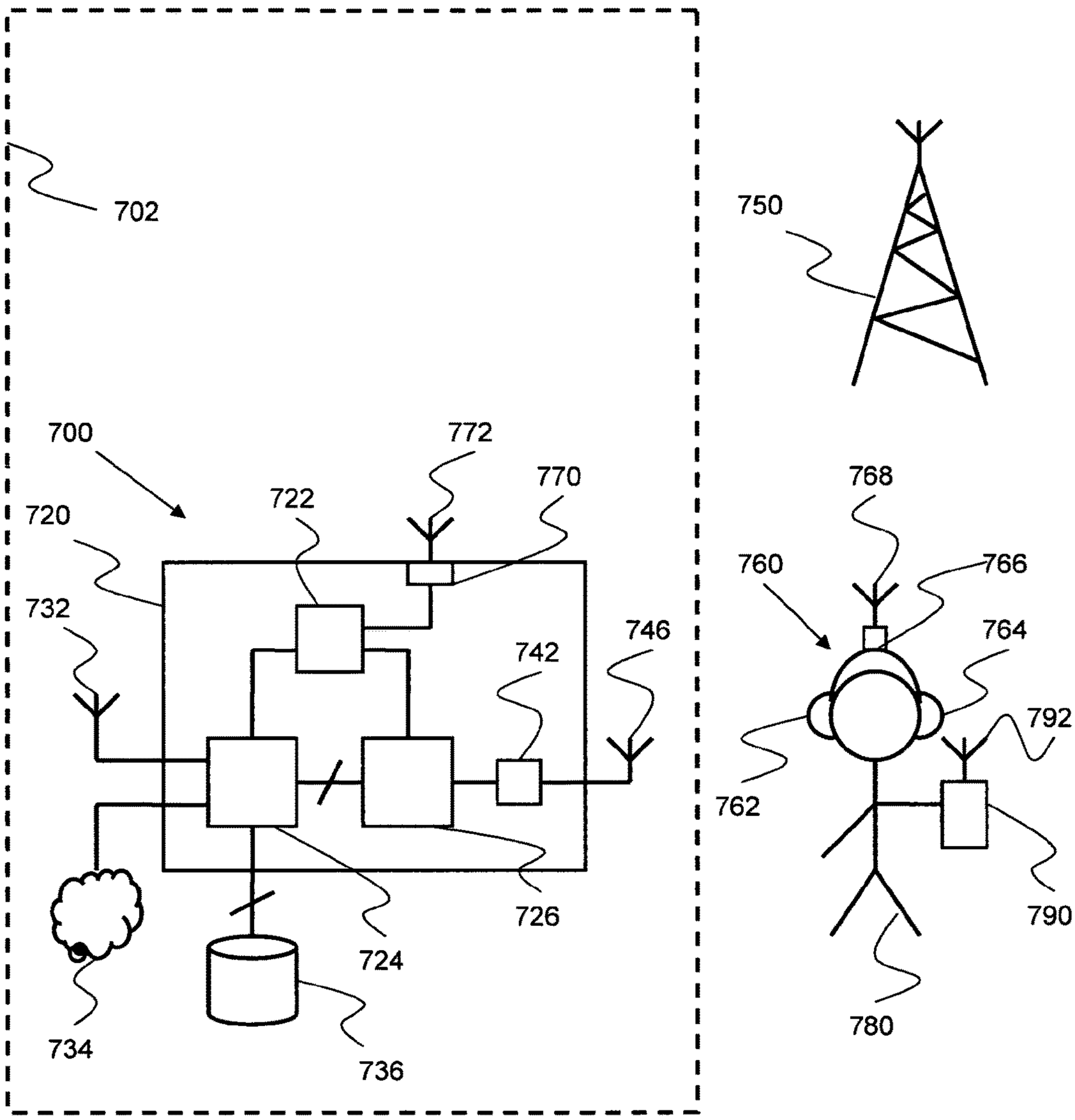


Fig. 6 B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700
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770
722
720
732
746
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724
734
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750
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760
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764
792
762
790
780

Fig. 7

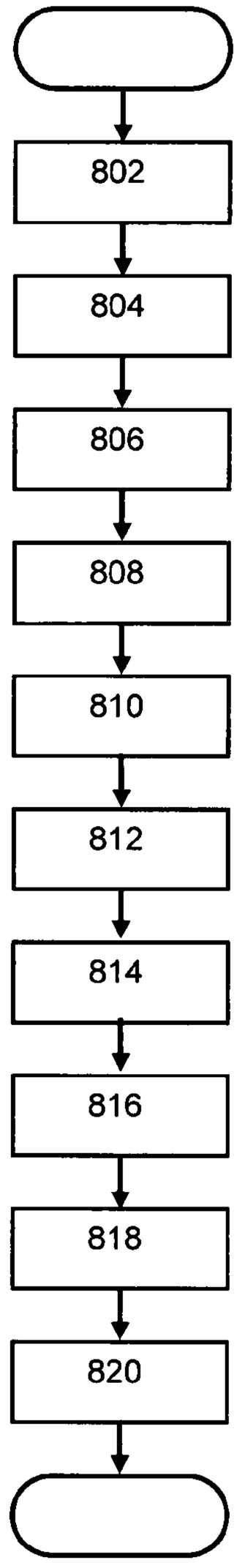

Fig. 8

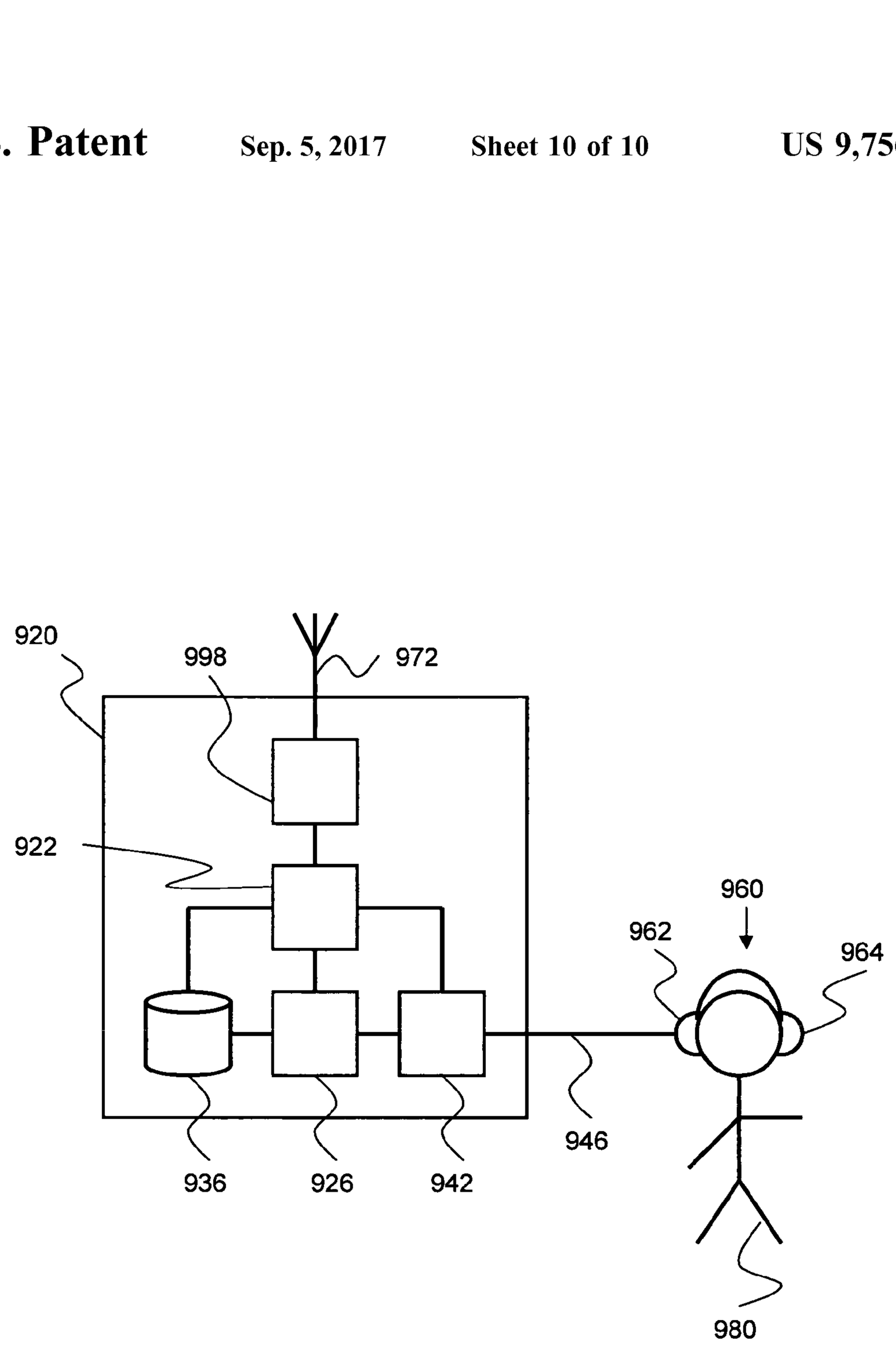

Fig. 9

METHOD AND DEVICE FOR PROCESSING SOUND DATA FOR SPATIAL SOUND REPRODUCTION

CROSS REFERENCE TO RELATED APPLICATIONS

This patent application is a U.S. nationalization under 35 U.S.C. §371 of International Application No. PCT/NL2012/050447, filed Jun. 25, 2012, which claims priority to Netherlands Patent Application No. 2006997, filed Jun. 24, 2011. The disclosures set forth in the referenced applications are incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

The invention relates to the field of sound processing and in particular to the field for creating a spatial sound image.

BACKGROUND OF THE INVENTION

Providing sound data in a realistic way to a listener, for example audio data accompanying a film on a data carrier like a DVD or BLURAY® disc, is done by pre-mixing sound data before recording it. The point of departure for such mixing is that the listener enjoys the sound data reproduced as audible sound at a fixed position, with speakers more or less provided at fixed positions in front of or around the listener.

OBJECT AND SUMMARY OF THE INVENTION

It is preferred to provide a more enhanced listening experience.

The invention provides in a first aspect a method of processing sound data comprising determining a listener position; determining a virtual sound source position; receiving sound data; processing the sound data for reproduction by at least one speaker to let the listener perceive the processed sound data reproduced by the speaker to originate from the virtual sound position.

In this way, the listener is provided with a more realistic experience of sound by the speaker.

In an embodiment of the method according to the invention, processing the sound data for reproduction comprises at least one of the following: processing the sound data such that when reproduced by the first speaker as audible sound results in a decrease of sound volume when the distance between the listener position and the virtual sound source position increases; or processing the sound data such that when reproduced by the first speaker as audible sound results in an increase of sound volume when the distance between the listener position and the virtual sound source position decreases.

With this embodiment, the listener can be provided with a more realistic experience of sound in a dynamic environment, where the listener, the virtual sound source or both have positions that are dynamic.

In a further embodiment of the method according to the invention wherein the processing of the sound data comprises processing the sound data for reproduction by at least two speakers, the two speakers are comprised by a pair of headphones arranged to be worn by a head of the listener; determining the listener position comprises determining an angular position of the headphones; processing the sound data for reproduction further comprises when the angular data indicates that the first speaker is closest to the virtual sound source position the sound data is processed such that when reproduced by the first speaker as audible sound results in an increase of sound volume and when reproduced by the second speaker as audible sound results in a decrease of sound volume.

With this embodiment, the experience of the listener is improved even further. Furthermore, with multiple headphones being operatively connected to a device that processes the audio data, individual listeners can be provided with individual experiences independently from one another, depending on their individual positions.

Another embodiment of the method according to the invention comprises providing a user interface indicating at least one virtual sound position and the listener position and the relative positions of the virtual sound position and the listener to one another; receiving user input on changing the relative positions of the virtual sound position and the listener to one another; processing further sound data received for reproduction by a speaker to let the listener perceive the processed sound data reproduced by the speaker to originate from the changed virtual sound position.

In this embodiment, data on positions is received in an efficient way and positions can be conveniently provided by a user of a device that processes the audio data.

The invention provides in a second aspect a method of recording sound data comprising: receiving first sound data through a first sound sensor; determining the position of the first sound sensor; storing the first sound data received by the sensor; storing first position data related to the position of the first sound sensor for later retrieval with the stored first sound data.

The invention provides in a third aspect a device for processing sound data comprising: a sound data receiving module for receiving sound data; a virtual sound position data receiving module for receiving sound position data; a listener position data receiving module for receiving a position of a listener; a data rendering unit for processing data arranged for processing the sound data for reproduction by at least one speaker to let the listener perceive the processed sound data reproduced by the speaker to originate from the virtual sound position.

The invention provides in a fourth aspect a device for recording sound data comprising: a sound data acquisition module arranged to be operationally connected to a first sound sensor for acquiring first sound data; and a position acquisition module for acquiring position data related to the first sound data; the device being arranged to be operationally connected to a storage module for storing the sound data and for storing the position data related to the position of the first sound sensor for later retrieval with the stored first sound data.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be discussed in further detail by means of Figures. In the Figures:

FIG. **1**: shows a sound recording system;

FIG. **2**: shows a home cinema set with speakers;

FIG. **3**: shows a flowchart;

FIG. **4**: shows a user interface;

FIG. **5**: shows a listener positioned between speakers reconstructing a spatial sound image with virtual sound sources;

FIG. **6** A: shows a home cinema set connected to headphones;

FIG. **6** B: shows a headphone transceiver in further detail;

FIG. **7**: shows a messaging device;

FIG. **8**: shows a flowchart; and
FIG. **9**: shows a portable device.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. **1** discloses a sound recording system **100** as an embodiment of the data acquisition system according to the invention. The sound recording system **100** comprises a sound recording device **120**. The sound recording device **120** comprises a microprocessor **122** as a control module for controlling the various elements of the sound recording device **120**, a data acquisition module **124** for acquiring sound data and related position data and a transmission module **126** that is connected to the data acquisition module **124** for sending acquired sound data and related data like position data. Optionally, a camera module (not shown) may be connected to the data acquisition module **124** as well.

The data acquisition module **124** is connected to a plurality of n microphones **142** for acquiring sound data and a plurality of n position sensing modules **144** for acquiring position data related to the microphones **142**. The data acquisition module **124** is also connected to a data carrier **136** as a storage module for storing acquired sound data and acquired position data. The transmission module **126** is connected to an antenna **132** and a network **134** for sending acquired sound data and acquired position data. Alternatively, the acquired sound data and acquired position data may be processed before it is stored or sent. The network **134** may be a broadcast network like a cable television network or an address based network like internet.

In the embodiment depicted by FIG. **1**, the microphones **142** record sound produced by a pop band **110** comprising a lead singer **110.1**, a guitarist **110.2**, a keyboard player **110.3** and a percussionist **110.4**. The guitarist **110.2** is provided with two microphones **142**; one for the guitar and one for singing. Sound of the electronic keyboard is acquired directly from the keyboard, without intervention of a microphone **142**. Preferably, the electronic keyboard provides data on its position with the sound data provided to the data acquisition module **124**. The position sensing modules **144** acquire data from a first position beacon **152.1**, a second position beacon **152.2** and a third beacon **152.3**. The beacons **152** are provided at a fixed location on or in the vicinity of a stage on which the pop band **110** is performing. In another alternative, the position sensing modules **144** acquire position data from one or more remote positioning systems, like GPS or Galileo.

With one microphone **142**, the performance of one specific artist at a specific location is acquired and with that, also position data of the microphone **142** is acquired by means of the position sensing modules **144**. With some artists running around the stage with their microphones **142** and/or instruments, it is noted that the position of the microphones **142** is not necessarily a static position. The sound and position data is acquired by the acquisition module **124**. Subsequently, the acquired data is either stored on the data carrier **136** or sent by means of the transmission module **126** and the antenna **132** or the network **134**, or a combination thereof. Preferably, the sound data is provided in separate streams, one stream per microphone **142**. Also, each acquired stream is provided with position data acquired by the position sensing device **144** that is provided with the applicable microphone.

The position data stored and/or transmitted may either absolute position indicating an absolute geographical location or positions of the position sensing modules **144** like latitude, longitude and altitude on the globe. Alternatively, relative positions of the microphones **142** are either acquired or calculated by processing information acquired on absolute geographical location of the microphones **142**.

Acquisition of relative positions of the microphones **142** is in a particular embodiment done by determining their positions with respect to the beacons **152**. With respect to the beacons **152**, a centre point is defined in the vicinity or in the centre of the pop band **110**. Subsequently, the coordinates of the position sensing modules **144** are determined based on the distances of the position sensing modules **144** from the beacons **152**.

Calculation of the relative positions of the microphones **142** is in a particular embodiment done by acquiring absolute global coordinates by the position sensing modules **144** by acquiring data from the GPS system. Subsequently, the absolute coordinates are averaged. The average is taken as the centre, after which the distance of each of the microphones **142** from the centre is calculated. This step results in coordinates per microphone **142** relative to the centre.

In yet another embodiment, the position of the microphones is pre-defined and particularly in a static way. This embodiment does not require each of the microphones **142** to be equipped with a position sensing device **144**. The pre-defined position data is stored or sent together with the sound data acquired by the microphones **142** to which the pre-defined position data relates. The pre-defined position data may be defined and added manually after recording. Alternatively, the pre-defined position data is defined during or after recording by identifying a general position of a band member on a stage, either automatically or manually.

Such embodiment can be used where the microphones **142** are provided at a pre-defined location. This can for example be the case when the performance of the pop band is recorded by a so-called soundfield microphone. A soundfield microphone records signals in three directions perpendicular to one another. In addition, the overall sound pressure is measured in an omnidirectional way. In this particular embodiment, the sound is captured in four streams, where three directional sound data signals are tagged with the direction from which the sound data is acquired. The position of the microphone is acquired as well.

In the embodiments discussed here, sound data acquired by a specific microphone **142**.*i* where i denotes a number from 1 to n where the sound recording system **100** comprises n microphones **142**, is stored with position data identifying the position of the microphone **142**.*i*, where the position data is either acquired by the position sensing device **144**.*i* or is pre-defined. Storing of the position data with the related sound data may be done by means of multiplexing of streams of data, storing position data in a table, either fixed or timestamped, or by providing a separate stream.

FIG. **2** discloses a sound system **200** as an embodiment of the sound reproduction system according to the invention. The sound system **200** comprises a home cinema set **220** as an audiovisual data reproduction device comprising a data receiving module **224** for receiving audiovisual data and in particular sound data from for example the sound recording device **120** (FIG. **1**) via a receiving antenna **232**, a network **234** or from a data carrier **236**, a rendering module **226** for rendering and amplifying audiovisual data on a screen **244** of a television or computer monitor and/or speakers **242**. In a preferred embodiment, the speakers **242** are arranged around a listener **280**.

The home cinema set **220** further comprises a microprocessor **222** as a controlling module for controlling the various elements of the home cinema set **220**, an infra-red

transceiver **228** for communicating with a remote control **250** and in particular for receiving instructions for controlling the home cinema set **220** and a sensing module **229** for sensing positions of the speakers **242** and a position of a listener listening to sound reproduced by the home cinema set **220**.

The working of the home cinema set **220** will be discussed in further detail in conjunction with FIG. **2** and FIG. **3**. FIG. **3** depicts a flowchart **300**, of which the table below provides short descriptions of the steps.

Step	Description
302	Receive sound data
304	Receive sound source position data
306	Determine speaker position
308	Determine listener position
310	Process sound data
312	Provide processed sound data to speakers

In a reception step **302**, the data receiving module **224** receives sound data via the receiving antenna **232**, the network **234** or the data carrier **236**. The data may be pre-processed by downmixing an RF signal received via the antenna **232**, by decoding packets received from the network **234** or the data carrier **236**, by other types of processing or a combination thereof.

In a position reception step **304**, position data related to the sound data is received by the data receiving module **224**. As discussed above in conjunction with FIG. **1**, such position data may be acquired while acquiring the sound data. As discussed above as well, the position data is or may be provided multiplexed with the sound data received. In such case, the sound data and the position data are preferably retrieved or received simultaneously, after which the sound data and the position data are de-multiplexed.

Subsequently, the position of each of the plurality of the speakers **242** is determined by means of the sensing module **229** in a step **306**. To perform this step, the sensing module **229** comprises in an embodiment an array of microphones. To determine the location of the speakers, the rendering module **226** provides a sound signal to each of the speakers **242** individually. By receiving the sound signal reproduced by the speaker **242** with the array of microphones, the position of the speaker **242** can be determined. The position can be determined in a two-dimensional way using a two-dimensional array of microphones or in a three-dimensional way using a three-dimensional array of microphones. Alternatively, instead of sound, radiofrequency or infrared signals and receivers can be used as well. In such case, the speakers **242** are provided with a transmitter arranged to transmit such signals. This step comprises m sub steps for determining the positions of a first speaker **242.1** through a last speaker **242.***m*. Alternatively, the positions of the speakers **242** is available in the home cinema system **220** and in the step **306** retrieved for further use

In a listener position determination step **308**, the position of the listener **280** listening to sound reproduced by the speakers **242** connected to the home cinema system is determined. The listener **280** may identify himself or herself by means of a listener transponder **266** provided with a transponder antenna **268**. Signals sent out by the transponder **266** are received by the sensing module **229**. For that purpose, the sensing module **229** is provided with a receiver for receiving signals sent out by the transponder **266** by means of the transponder antenna **268**. Alternatively or additionally, the position of the listener **280** is acquired by means of one or more optical sensors, optionally enhanced with face recognition. In particular in such alternative, the sensing module **229** is embodied as the "KINECT®" device as provided for working in conjunction with the XBOX® game console.

Having received sound source position data, sound data, the position of the listener and the positions of the speakers, the sound data received is processed to let the listener **280** perceive the processed sound data reproduced by the speakers **242** to originate from a virtual sound position. The virtual sound position is the position where sound is to be perceived to originate from, rather than a position where the speakers **242** are located. By receiving sound data as audio streams recorded per individual member of the pop band **110** (FIG. **1**), together with information on the position of each individual member of the pop band **110** and/or positions of microphones **142** and/or electrical or electronic instruments, a spatial sound image provided by the live performance of the pop band **110** can be reconstructed in a room where the listener **280** and the speakers **242** are located.

The spatial sound image may be reconstructed with the listener **280** perceiving to be in the centre of the pop band **110** or rather perceiving to be in front of the pop band **110**. Such preferences may be entered via a user interface **400** as depicted by FIG. **4**. The user interface **400** provides a perspective view window **410**, a top view window **412**, a side view window **414** and a front view window **416**. Additionally, a source information window **420** and a general information window **430** are provided. The user interface **400** can be visualised on the screen **244** or a remote control screen **256** of the remote control **250**.

The perspective view window **410** presents band member icons **440** indicating the positions of the members of the pop band **110** as well as a position of a listener icon **450**. Per default, the members of the pop band **110** are presented based on position data received by the data receiving module **224**. Here, the relative positions of the members of the pop band **110** to one another are of importance. The listener icon **450** is per default presented in front of the band. Alternatively, the listener icon **450** is placed at that or another position as determined by position data accompanying the sound data received. By means of navigation keys **254** provided on the remote control **250**, a user of the home cinema system **220** and in particular the listener **280** is enabled to move the icons around in the perspective view window **410**. Alternatively or additionally, the user interface **400** is provided on a touch screen and can be controlled by operating the touch screen. The icons provided in the top view window **412**, the side view window **414** and the front view window **416** move accordingly with moving the icons in the perspective view window **410**.

Upon moving the listener icon **450** relative to the pop member icons **440** in the user interface **400** by means of the navigation keys **254**, a spatial sound image provided by the speakers **242** in step **312** is reconstructed differently around the listener **280**. If the listener icon **450** is shifted to be in the middle of the pop band icons **440**, the spatial sound image provided by the speakers is arranged such that the listener **280** is provided with a first virtual sound source of the lead singer indicated by a first artist icon **440.1** behind the listener **280**. The listener **280** is provided with a second virtual sound source of the keyboard player indicated by a second artist icon **440.2** at the left, a third virtual sound source of the guitarist indicated by a third artist icon **440.3** at the right and a fourth virtual sound source of the percussionist indicated by a fourth artist icon **440.4** in front of the listener **280**. So the positions of the virtual sound sources are determined or

defined by the position data provided with the sound data as received by the data receiving module **224**, the positions of the pop member icons and the listener icon **450**.

While turning the listener icon **450** 180 degrees around its vertical axis in the user interface **400**, the first virtual sound source would move from the back of the listener **480** to the front of the listener **480**. Other virtual sound sources move accordingly. Additionally or alternatively, the virtual sound sources can also be moved by moving the pop member icons **440**. This can be done as a group or by moving individual pop member icons **440**.

Additionally or alternatively, the relative position of the listener **280** with respect to the virtual sound sources of the individual artists of the pop band **110** is determined by means of the listener transponder **266** and in particular by means of the signals emitted by the listener transponder **266** received by the sensing module **229**. Those skilled in art will appreciate the possibility to determine the acoustic characteristics of the environment, which can be used in the sound processing.

The reconstruction of the spatial sound image with the virtual sound sources is provided by the rendering module **226**, instructed by the microprocessor **222** based on input received from the remote control **250** to control the user interface **450**. This is depicted by FIG. **5**. FIG. **5** depicts a listener **280** surrounded by a first speaker **242.1**, a second speaker **242.2**, a third speaker **242.3**, a fourth speaker **242.4**, and a fifth speaker **242.5**. Sound data previously recorded by means of a microphone **142.1** (FIG. **1**) provided with the lead singer **110.1** is particularly processed by the rendering module **226** such that this sound data is provided to and reproduced by the first speaker **242.1** and the second speaker **242.2**. Sound data previously recorded by a microphone **142.2** (FIG. **1**) provided with the guitarist **110.2** is particularly processed by the rendering module **226** such that this sound data is provided to and reproduced by the second speaker **242.2** and by the fourth speaker **242.4** to a less extent. Additionally or alternatively, psycho-acoustic effects may be employed. Such psycho-acoustic effects may include processing the sound data by filters like comb filters to create surround or pseudo-surround effects.

If a user like the listener **280** rearranges the band member icons **440** and/or the listener icon **450** on the user interface **400** such that all band member icons **440** appear in front of the listener icon **450**, this information is processed in step **310** by the microprocessor **222** and the rendering module **226** to define the virtual sound positions in front of the listener **280** and have the sound data related to the lead singer **110.1**, keyboard player **110.3**, guitarist **110.2** and percussionist **110.4** mainly reproduced by the first speaker **242.1**, the second speaker **242.2** and the third speaker **242.3**. With the listener icon **450** and a specific band member icon **440** being moved apart on the user interface **400**, the sound related to that band member icon will be reproduced with a reduced volume to let the virtual sound source of that band member be perceived as being positioned further away from the listener **280**

The embodiments discussed above work in particular well with one listener **280** or multiple listeners sitting closely together. In scenarios with multiple listeners being located further apart from one another, virtual sound sources are more difficult to define for each individual listener in a proper way with a set of speakers in a room where the listeners are located. In such scenarios, headphones are preferred. Such scenario is depicted by FIG. **6**.

FIG. **6** A discloses a sound system **600** as an embodiment of the sound reproduction system according to the invention. The sound system **600** comprises a home cinema set **620** as an audiovisual data reproduction device, comprising a data receiving module **624** for receiving audiovisual data and in particular sound data from for example the sound recording device **120** (FIG. **1**) via a receiving antenna **632**, a network **634** or from a data carrier **636**, a rendering module **626** for rendering and amplifying audiovisual data on a screen **644** of a television or computer monitor and/or via one or more pairs of headphones **660.1** through **660.***n* via a headphone transmitter **642** that is connected to a headphone transmitter antenna **646**.

The home cinema set **620** further comprises a microprocessor **622** as a controlling module for controlling the various elements of the home cinema set **620**, an infra-red transceiver **628** for communicating with a remote control **650** and in particular for receiving instructions for controlling the home cinema set **620** and a headphone position detection module **670** with a headphone detection antenna **672** connected thereto for determining positions of the headphones **660** and with that one or more positions of one or more listeners **680** listening to sound reproduced by the home cinema set **620**.

The headphones **660** comprise a left headphone shell **662** and a right headphone shell **664** for providing sound to a left ear and a right ear of the listener **680**, respectively. The headphones **660** are connected to a headphone transceiver **666** that has a headphone antenna **668** connected to it.

The home cinema set **620** as depicted by FIG. **6** A works to a large extend similar to the home cinema set **220** as depicted by FIG. **2**. Instead of or in addition to having speakers **242** (FIG. **2**) connected to it, the rendering module **626** is connected to the headphone transmitter **642**. The acoustic characteristics of the headphones **660** are related to the individual listener, so the rendering module **626** may use generalised or individualised head related transfer function or other methods of sound processing for a more realistic sound experience. The headphone transmitter **642** is arranged to provide, by means of the headphone transmitter antenna **646**, sound data to the headphone transceiver **666**. In turn, the headphone transceiver **666** receives the audio data sent by means of the headphone antenna **668**. FIG. **6** B depicts the headphone transceiver **666** in detail.

The headphone transceiver **666** comprises a headphone transceiver module **692** for downmixing sound data received from the home cinema set **620**. The headphone transceiver **666** further comprises a headphone decoding module **694**. Such decoding may comprise downmixing, decompression, decryption, digital-to-analogue conversion, filtering, other or a combination thereof. The headphone transceiver **666** further comprises a headphone amplifier module **696** for amplifying the decoded sound data and for providing the sound data to the listener **680** in an audible format by means of the left headphone shell **662** and the right headphone shell **664** (FIG. **6** A).

The headphone transceiver **666** further comprises a position determining module **698** for determining the position of the headphone transceiver **666** and with that the position of the listener **680**. Position data indicating the position of the headphone transceiver **666** is by means of the headphone transceiver module **692** and the headphone antenna **668** sent to the home cinema set **620**. The home cinema set **620** receives the position data by means of the headphone position detection module **670** and the headphone detection antenna **672**. Position parameters comprised by the position data that can be determined by the position determining module **698** may include, but are not limited to, distance between the headphone detection antenna **672** and the

headphone transceiver **666**, bearing of the headphone transceiver **666**, Cartesian coordinates, either relative to the headphone detection antenna or absolute global Cartesian coordinates, spherical coordinates, either relative or absolute on a global scale, other or a combination thereof. Absolute coordinates or a global scale can for example be obtained by means of the Global Positioning System, the Galileo satellite navigation system. Relative coordinates can be obtained in a similar way, with the headphone position detection module **670** fulfilling the role of satellites in global position determining systems.

The headphone transmitter **642** as well as the headphone position detection module **670** are arranged to communicate with multiple headphones **660**. This allows the home cinema system **620** to provide each of the n listeners from the first listener **680**.**1** through the nth listener **680**.*n* with his or her own spatial sound image. For providing separate spatial sound images for each of the listeners **680**, the virtual sound positions as depicted in FIG. **5** are in one embodiment defined at fixed positions in a room where the listeners **680** are located. In another embodiment, the virtual sound positions are differently defined for each of the listener. This may be enhanced by providing each individual listener **680** with a dedicated user interface **400**.

The first of these two latter embodiments is particularly advantageous if two or more listeners are free to move in a room. By walking or otherwise moving through the room, a listener **680** can move closer to a virtual sound source position defined in the room. By moving closer, the sound related to that virtual sound position is reproduced at a higher volume by the left headphone shell **662** and the right headphone shell **664**. Furthermore, if this listener **680** turn 90 degrees clockwise around his or her top axis, the spatial sound image provided to and reproduced by the left headphone shell **662** and the right headphone shell **664** is also turned 90 degrees, independent from other spatial sound images provided to other headphones **660** of other listeners **680**. This embodiment is in particular advantageous in an Imax theatre or equivalent theatre with multiple screens or a museum where an audio guide is provided. In the latter case, the virtual sound source would be a painting where people move around. The latter scenario is particularly advantageous as one would not have to search for a painting by means of tiny numbers provided next to paintings.

The second of these latter embodiments is particularly advantageous if multiple listeners **680** prefer other listening experiences. A first listener **680**.**1** may prefer to listen to the sound of the pop band **110** (FIG. **1**) as experienced in the middle of the pop band **110**, whereas a second listener **680**.**2** may prefer to listen to the sound of the pop band **110** as experienced while standing ten meters in front of the pop band **110**.

In both cases, each of the n headphones **660** is provided with a separate spatial sound image. The spatial sound images are constructed based on sound streams received by the data receiving module **624**, position data related to those sound streams indicating virtual sound source positions for these sound streams, virtual sound source positions defined for example by means of a user interface as or similar to the user interface **400** (FIG. **4**), positions of the listeners in a room, either absolute or relative to the headphone position detection module **670**, other, or a combination thereof.

FIG. **7** depicts another embodiment of the invention in another scenario. FIG. **7** shows a commercial messaging system **700** comprising a messaging device **720**. The messaging device is arranged to send commercial messages to one or more listeners **780**. The messaging device **720** comprises a data receiving module **724** for receiving audiovisual data and in particular sound data from for example the sound recording device **120** (FIG. **1**) via a receiving antenna **732**, a network **734** or a data carrier **736**, a rendering module **726** for rendering and amplifying audiovisual data via one or more pairs of headphones **760** via a headphone transmitter **742** that is connected to a headphone transmitter antenna **746**. The pair of headphones **760** comprises a left headphone shell **762** and a right headphone shell **764** for providing audible sound data to the listener **780**.

In one embodiment, the pair of headphones **760** comprises a headphone transceiver **766** that has a headphone antenna **768** connected to it. The headphone transceiver **766** comprises similar or equivalent modules as the headphone transceiver **666** as depicted by FIG. **6** B and will not be discussed in further detail. In another embodiment, the pair of headphones **760** does not comprises a headphone transceiver. In this particular embodiment, the pair of headphones **760** is connected to a mobile telephone **790** held by the listener **780** for providing sound data to the pair of headphones **760**. The mobile telephone comprises in this embodiment similar or equivalent modules as the headphone transceiver **666** as depicted by FIG. **6** B.

The messaging device **720** further comprises a microprocessor **722** as a controlling module for controlling the various elements of the home cinema set **720** and a listener position detection module **770** with a headphone detection antenna **772** connected thereto for determining positions of the headphones **760** and with that one or more positions of one or more listeners **780** listening to sound reproduced by the messaging device **720**. Alternatively, the position of the listener **780** is determined by determining the position of the mobile telephone **790** held by the listener **780**. More and more mobile telephones like the mobile telephone **790** depicted by FIG. **7** comprise a satellite navigation receiver, by means of which the position of the mobile telephone **790** can be determined. Additionally or alternatively, the position of the mobile telephone **790** is determined by a triangular measurement determining the position of the mobile telephone **790** relative to multiple and preferably at least three base stations or beacons of which the position is know.

The commercial messaging system **700** is particularly arranged for sending commercial messages or other types of messages that are by the listener **780** perceived as originating from a particular location, either dynamic (mobile) or static (fixed). In a particular scenario in a street with a shop **702** in or close to which the commercial messaging system **700** is located, the listener **780** and his or her location are obtained by the commercial messaging system **700** by receiving position data related to the listener **780**. Subsequently, sound data is rendered such that with the rendered or processed sound data being provided to the listener **780** by means of the pair of headphones **760**, the sound reproduced by the pair of headphones **760** appears to originate by the shop **702**. This will be further elucidated by means of a flowchart **800** depicted by FIG. **8** and of which the table below provides short descriptions of the steps.

Step	Description
802	Identify listener
804	Request listener position data
806	Determine listener position
808	Send listener position data
810	Receive listener position data
812	Retrieve sound data

-continued

Step	Description
814	Render sound data
816	Transmit rendered sound data
818	Receive rendered sound data
820	Reproduce rendered sound data

In step **802**, the listener **780** identifies himself or herself by means of the mobile telephone **790** as a mobile communication device. This can for example be established by the listener **780** moving into a specific communication cell of a cellular network, which communication cell comprises the location of the shop **702**. Entry of the listener **780** in the communication cell is detected by a base station **750** in the communication cell taking over communication to the mobile telephone **790** from another base station of another communication cell.

Upon the entry of the listener **780** in the communication cell, the listener **780** is identified by means of the International Mobile Equipment Identity (IMEI) of the mobile telephone **790** or the number of the Subscriber Identity Module (SIM) of the mobile telephone **790**. These are elements that are part of for example the GSM standard and subsequent generations thereof. Additionally or alternatively, other data may be used for identifying the listener **780**. In the identification step, it is optionally determined whether the listener **780** wishes to receive commercial messages and in particular commercial sound messages. If the listener **780** desires not to receive such messages, the process depicted by the flowchart **800** terminates. The identification of the listener **780** is communicated from the base station **750** to the messaging device **720**.

Alternatively, the listener **780** is identified directly by the messaging device **720** by means of other network protocols and/or standards than used for mobile telephony, like WiFi in accordance with any of the IEEE 802.11 standards, WiMax or another network. In particular upon entry of the listener **780** in the range of the headphone transmitter **742** or the listener position detection module **770**, the listener **780** is detected and queried for identification and may be connected to the messaging device **720** via a wireless communication connection.

After identification of the listener **780**, the listener **780**, the mobile telephone **790** and/or the headphone transceiver **766** are queried for providing position data related to the position of the listener **780** in a step **804**. In response to this query, a position determining module comprised either by the mobile telephone **790** or the headphone transceiver **766** determines its position in a step **806**. As the mobile telephone **790** or the headphone transceiver **766** are held by the listener **780**, the positions are substantially the same.

The position data may comprise coordinates of the position of the listener on the earth, provided by latitude and longitude in degrees, minutes and seconds or other entities and altitude in meters or another entity. Such information may be obtained by means of a navigation system like the Global Positioning System, the Galileo system, another navigation system or a combination thereof. Alternatively, the position data may be obtained on a local scale by means of local beacons. In a particular preferred embodiment, the bearing of the listener **780** and in particular of the head of the listener **780** is provided. Alternatively, the heading of the listener **780** is determined by following movements of the listener **780** for a pre-determined period in time. These two parameters—heading and bearing will be referred to as angular position of the listener **780**. After the position data has been obtained, it is sent to the messaging device **720** in a step **808** by means of a transceiver module in the headphone transceiver **766** or the mobile telephone.

The position data sent is received by the listener position detection module **770** with the headphone detection antenna **772** in a step **810**. In certain embodiments, the position data received requires post processing. This is in particular the case if the position data comprises coordinates of the listener on the earth, as in this scenario the position of the listener relative to the messaging device **720** and/or to a shop **702** to which the messaging device **720** is related is a relevant parameter. In case the position data is determined by means of dedicated beacons, for example located close to the messaging device **720**, the position of the listener **780** relative to the messaging device **720** may be determined directly and sent to the messaging device.

Subsequently, sound data to be provided to the listener **780** is retrieved by the data receiving module **724** in a step **812**. Such sound data is in this scenario a commercial message related to the shop **702** to catch the interest of the listener **780** to visit the shop **702** for a purchase. Upon retrieval of the sound data by the data receiving module **724** from a remote source via the receiving antenna **732**, the network **734** or from the data carrier **736**, the sound data is rendered in a step **814** by the rendering module **726**. The rendering step is instructed and controlled by the microprocessor **722** employing the position data on the position of the listener **780** received earlier. A person skilled in the art will appreciate that the rendered sound may be rendered in an individualised way based on the identification of the listener **780** in the step **802**. For example, the listener **780** may provide further information enabling the messaging device **720** and in particular the rendering module **726** identifying the listener **780** as a particular individual having for example particular preferences on how sound data is preferred to be received.

The sound data is rendered such that when reproduced in audible format by the left headphone shell **762** and the right headphone shell **764** of the pair of headphones **760**, a source of the sound appears to be the location of the shop **702**. This means that the sound data is rendered to provide the listener with a spatial sound image via the pair of headphones **760** with the shop **702** as a virtual sound source, so where the shop **702** is a virtual sound source position. When the listener **780** approaches the shop **702** from the north through a street, where the shop **702** is located on the right side of the street, the sound rendered and provided by the pair of headphones **760** is by the listener perceived as coming from the south, from a location in front of the listener **780**.

While getting closer to the shop, the sound will appear more and more from the south west, so from the right front of the listener **780** and the volume of the sound will increase. Optionally, when also data on the angular position of the listener is available and when the listener turns his or her head, the spatial sound image will be provided accordingly. This means that when the listener **780** turns his or her head to the right, the sound rendered to be perceived to originate from the virtual sound source position of the shop, so the sound will be provided more via the left headphone shell **762**. So the sound data retrieved by the data receiving module **724** will be rendered by the rendering module **726** using the position data received such that in the perception of the listener, the sound will always appear to originate from a fixed geographical location.

In a subsequent step **816**, the rendered sound data comprising the spatial sound image thus created is transmitted by

the headphone transmitter **742**. The sound data may be transmitted to the mobile telephone **790** to which the pair of headphones is operatively connected for providing sound data. Alternatively, the sound data is sent to the headphone transceiver **766**.

The rendered sound data thus sent is received in a step **818** by the headphone transceiver **766** or the mobile telephone **790**. In the latter case, the sound data may be transmitted via a cellular communication network like a GSM network, though a person skilled in the art will appreciate that this may not always be advantageous in view of cost, depending on the subscription of the listener **780**. Rather, the sound data is transmitted via an IEEE 802.11 protocol or an equivalent public standardised or proprietary protocol.

The sound data received is subsequently mixed down, decoded, amplified, processed otherwise or a combination thereof and provided to the left headphone shell **762** and the right headphone shell **764** of the pair of headphones **760** for reproduction of the rendered sound data in an audible format, thus constructing the desired spatial sound image and providing that to the listener **780**.

In a similar scenario depicted by FIG. **9**, sound data may also be provided to a listener **980** without an operational communication link between the messaging device **720** (FIG. **7**) and a device carried by the listener **980**.

The mobile device **920** comprises a storage module **936**, a rendering module **926**, a headphone transmitter **942**, a position determining module **998** connected to a position antenna **972** and a microprocessor **922** for controlling the various elements of the mobile device **920**. The mobile device **920** is via a headphone connection **946** connected to a pair of headphones **960** comprising a left headphone shell **962** and a right headphone shell **964** for providing sound in audible format to a left ear and a right ear of the listener **980**. The headphone connection **946** may be an electrically conductive connection or a wireless connection, for example in accordance with the BLUETOOTH® protocol or a proprietary protocol.

In the storage module **936**, sound data is stored. Additionally, position data of a geographical location is stored, that is in this scenario related to a shop. Alternatively or additionally, position data related to or indicating geographical location of other places or persons of interest may be stored. The position data may be fixed (static) or varying (dynamic). In particular in case the position data is dynamic, but also in case the position data is static, it may be updated in the storage module **936**. The updates would be received through a communication module comprised by the mobile device **920**. Such communication module could be a GSM transceiver or equivalent for that purpose. The stored position data is in this scenario the virtual sound source position, which concept has been discussed before.

The sound data is provided to the rendering module **926**. The stored position data is be provided to the microprocessor **922**. The position determining module **998** determines the position of the mobile device **920** and with that the position of listener **980**. The listener position can be determined by receiving signals for satellites of the GPS system, the Galileo system or other navigation or location determination systems via the position antenna **972** and in case required, post processing the information received. The listener position data is provided to the microprocessor **922**.

The microprocessor **922** determines the listener position and the stored position relative to one another. Based on the results of this processing, the rendering module **926** is instructed to render the provided sound data such that the listener perceives audible sound data provided to the pair of headphones **960** to originate from a location defined by the stored position data.

Providing the rendered sound data to the listener can be triggered in various ways. In a preferred embodiment, the listener position is determined continuously or a regular intervals, preferably at periodical intervals. The listener position data is upon acquisition processed together with one or more locations identified by stored position data by the microprocessor **922**. When the listener **980** is within a pre-determined range of a location identified by stored position data, for example within a radius of 50 meters from the location, the portable device **920** retrieves sound data associated with the location and will start rendering the sound data as discussed above.

As discussed above, in case the position data is dynamic, but also in case the position data is static, it may be updated in the storage module **936**. This is advantageous in a scenario where the listener **980** listens to and in particular communicates with a mobile data source like another listener. In one scenario, the other listener continuously or at least regularly communicates his or her position to the listener **980**, together with sound information, for example a conversation between the two listeners. The listener **980** would perceive sound data provided by the other listener as originating from the position of the other listener. Position data related to the other listener is received through the position determining module **998** and used for processing of sound data received for creating the desired spatial sound image. The spatial sound image is constructed such that when provided to the listener **980**, the listener would perceive the sound data as originating directly from the position of the other listener.

This embodiment, but also other embodiments can also be employed in city tours, a museum or exhibition with several items on display, like paintings. As the listener **780** comes within a ten meters range of a painting, data on the painting will automatically be provided to the listener **780** in an audible format as discussed above, with a virtual sound source being located at or near the painting. Alternatively or additionally, ambient sounds may be provided with the data on the painting enhancing the experience of the painting. For example, if the listener **780** would be provided with sound data on the painting "La gare Saint Lazare" of Claude Monet with the location of the painting in the museum as a virtual sound source for the data discussing the painting, the listener can also be provided with an additional spatial sound image with railway station sounds being perceived to originate from a sound source other than the painting, so having another virtual sound source. In a city tour, this and other embodiments can also be combined with a mobile information application like Layar and other.

The invention claimed is:

1. A method of processing sound data comprising:

a) receiving sound data comprising a plurality of streams, each of said plurality of streams corresponding to a single specific artist and consisting of:

a sound recording of said single specific artist recorded by a single microphone, and

location data indicating a position of said single specific artist during said sound recording by said single microphone;

b) defining for each of said plurality of streams a virtual sound source position which per default represents the position of the single specific artist during said sound recording of the respective stream,

c) defining a relative position of a listener with respect to each of said virtual sound source positions; and

d) receiving, from a user interface, user input for moving one of said relative position of said listener or at least one of said virtual sound source positions; and

e) processing the sound data for reproduction through at least two speakers to let the listener perceive the processed sound data reproduced by the two speakers to originate from said virtual sound source positions in accordance with the position of said listener relative to said virtual sound source positions.

2. The method according to claim **1**, wherein processing the sound data for reproduction comprises at least one of the following:

a) processing the sound data such that when reproduced by a first speaker of said at least two speakers as audible sound results in a decrease of sound volume when a distance between said relative position of said listener and one of said virtual sound source positions increases; or

b) processing the sound data such that when reproduced by a first speaker of said at least two speakers as audible sound results in an increase of sound volume when a distance between said relative position of said listener and one of said virtual sound source positions decreases.

3. The method according to claim **1**, wherein

a) the two speakers are comprised by a pair of headphones arranged to be worn by a head of the listener;

b) determining the relative position of the listener comprises determining an angular position of the headphones; and

c) processing the sound data for reproduction further comprises when the angular data indicates that a first speaker of said at least two speakers is closest to the virtual sound source positions the sound data is processed such that when reproduced by the first speaker of said at least two speakers as audible sound results in an increase of sound volume and when reproduced by a second speaker of said at least two speakers as audible sound results in a decrease of sound volume.

4. The method according to claim **1**, wherein determining the relative position of the listener comprises at least one of the following:

a) receiving sensor data indicating a position of the listener;

b) receiving pre-determined data on a position of the listener;

c) receiving geolocation data indicating a position of the listener; or

d) receiving location data by means of a user input.

5. The method according to claim **4**, wherein the pre-determined data on a position of the listener is

a) received from a device available in close proximity of the listener; or

b) provided with the sound data.

6. The method according to claim **1**, wherein processing the sound data for reproduction comprises determining a relative position of the listener relative to a first speaker and/or a second speaker.

7. The method according to claim **1**, wherein determining the virtual sound source positions comprises at least one of the following:

a) receiving user input indicating the virtual sound source positions; or

b) receiving sound source position data provided with the sound data.

8. The method according to claim **1**, further comprising:

a) providing a user interface indicating at least one virtual sound position and the listener position and the relative positions of the virtual sound position and the listener to one another;

b) receiving user input on changing the relative positions of the virtual sound position and the listener to one another; and

c) processing further sound data received for reproduction by a speaker to let the listener perceive the processed sound data reproduced by the speaker to originate from the changed virtual sound position.

9. A device for processing sound data comprising:

a) a sound data receiving module, configured for receiving sound data comprising a plurality of streams, each of said plurality of streams corresponding to a single specific artist and consisting of:

a sound recording of said single specific artist recorded by a single microphone, and

location data indicating a position of said single specific artist during said sound recording by said single microphone;

b) a microcontroller, configured for defining for each of said plurality of streams a virtual sound source position which per default represents the position of the single specific artist during said sound recording of the respective stream;

c) a listener position data receiving module, configured for defining a relative position of a listener with respect to each of said virtual sound source positions; and

c) a user interface configured for receiving user input for moving one of said relative position of said listener or at least one of said virtual sound source positions; and

d) a data rendering unit, configured for processing the sound data for reproduction through at least two speakers to let the listener perceive the processed sound data reproduced by the two speakers to originate from said virtual sound source positions in accordance with the position of said listener relative to said virtual sound source positions.

10. The device according to claim **9**, wherein the listener position data receiving module comprises at least one sensor for sensing a position of the listener.

11. The device according to claim **9**, wherein the microcontroller is connected to a memory module and configured for storing the virtual sound source positions.

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